POWER ELECTRONICS CAPACITORS

MKV SERIES

Self healing
Bi-metallized paper
capacitors for
heavy duty AC applications

CERT. N.9170 ICAR

UNI EN 29001 (ISO 9001)

technology looking ahead

1. COMPANY PROFILE

OUR MISSION:
"Develop and supply high-quality capacitors, providing all the customers with full assistance from the design through the delivery.
We will take care to any particular needs that the customer may have."

Established in 1946, ICAR has rapidly reached, and since then maintained, a leadership position in the research and development of new capacitors and components of which capacitors are key parts.
In the early 60's, first in the world, ICAR started the production of metallized polypropylene film capacitors, by developing the film metallization by its own.
ICAR group nowadays controls all the manufacturing phases of the capacitor: from the polypropylene film extrusion through its metallization, to the production of the finished capacitor. The know-how accrued in almost 50 years of metallized film production, has enabled ICAR to bring to the market innovative products.
Today ICAR Group is a leader in the production of capacitors, both for power electronics applications and for low and medium voltage power factor correction.

ICAR Group today offers a wide range of products, all manufactured at its 6 plants located in Europe, that includes:

- power electronics and special capacitors
- lighting capacitors
- motor run capacitors
- Power Factor Correction capacitors and Systems
- L.V. and M.V. voltage stabilizers
- transformers and chokes

2. ICAR GROUP PRODUCT RANGE

POWER ELECTRONICS AND SPECIAL CAPACITORS

Polypropylene film capacitors for:
- DC link input filter both for industrial and traction inverters (LNK series and BIOENERGY D series)
- AC filter for inverters and UPS (LNF series)
- snubber capacitors for semiconductors (THY and MKV series)
- all purpose AC and DC capacitors (MKV and BIOENERGY A series)
- medium frequency furnaces (BIOFURN Series) and medical application
- special capacitors for energy storage

M.V. PFC CAPACITORS AND BANKS

Wide range of M.V. power capacitors, with powers from 50 to 800 kvar, available in single and three phase versions, up to 24 kV rated voltage.
Capacitor banks up to 150 kV both for indoor and outdoor installation can be supplied on customer need.

LIGHTING CAPACITORS

ICAR series of lighting capacitors are suitable for parallel and series power factor correction applications in both fluorescent and discharge light fittings.
Moreover Plastic Case Type A and Metal Case Type B capacitors can be equipped with a wide range of fixing devices and terminals options.
ENEC and UL approvals certify that ICAR lighting capacitors are in compliance with the latest standards and assures customers of an ICAR product with high levels of quality and reliability.

MOTOR RUN CAPACITORS

ICAR motor run capacitor product range is one of the largest on the market.
The polypropylene film capacitors are available for different levels of voltage from 250V up to 500V with long life ratings up to 30.000 hours.
The variety of terminations and fixings shown in our catalogue gives the possibility to use these capacitors in any kind of application. The special design of ICAR capacitors distinguishes these components both for their quality and for their reliability.
IMQ, VDE and UL approvals guarantee the ICAR motor capacitor range meets with international standards.

POWER CAPACITORS AND PFC CONTROLLERS

Aluminium can three phase capacitors of the CRT range are available for voltages from 230V to 800V and reactive powers ranging from 1 to 40 kvar.
Power Factor Correction Controllers of 5 to 12 steps, enjoys features like incorporated temperature sensors and control, alarms and protection functions.

PFC SISTEMS AND HARMONIC FILTERS

Range is complete of fix and automatic LV power factor correction systems, standard and detuned, active and passive harmonic absorption filters.
All of automatic systems have undergone type tests at International Laboratories

VOLTAGE STABILISERS

Electrodynamics and static voltage stabilisers, single-phase and three-phase, LV and MV from 1 up to 4000kVA with microprocessor control system. Electrodynamics line conditioners, single-phase and three-phase, LV and MV from 1 up to 2000kVA with microprocessor control system.

TRANSFORMERS AND CHOKES

Single-phase and three-phase MV and LV Electric Transformers for galvanic isolation, UPS and rectifiers.
Epoxy resin MV Transformers for distribution and rectifiers.
Single-phase and Three-phase MV and LV reactors and chokes for power correction system and AC/DC filters.

3. QUALITY POLICY

ICAR, a synonym for capacitor since 1946, has always considered the quality and the effectiveness of its internal processes as a key-factor in the company strategy.
The compliance with International Standards has always been kept as a fundamental reference for offering products and processes which completely match customers' requirements and expectations.
ICAR Quality System is certified according to EN ISO 9001:2008 standard.

CSQ
CISQ is a member of IQNet
CERTIFICATO N. 9170.ICAR
CERTIFICATE N.
ICAR SPA
ISO 9001:2008
1994-10-05
2009-06-11
2012-05-29
SINCERT
CISQ

ICAR representatives are members of the most important international standard committees, in charge for issuing the reference standards for the capacitor industry.
In order to comply with the international regulations and with the most severe customers acceptance criteria, products are submitted to tests both in the internal laboratories and in the most important internationally recognized laboratories

4. SELECTION RULES AND DEFINITIONS

SELECTION RULES

VOLTAGE

Select a capacitor with surge peak voltage (U_S), rated voltage (U_{NDC}) and rms voltage (U_{rms}) higher than the operating ones.

Consider that the rated voltage U_{NDC} shall be higher than the sum of the DC component and the repetitive peak of the AC component.

It is possible, within certain limits, to work above the rated voltage but this reduces the expected life of the capacitor.

During switching working condition, residual voltage before re-energizing shall not exceed 10% the rated voltage.

CURRENT AND FREQUENCY RANGE

Select a capacitor with maximum current I_{max}, higher than the operating I_{RMS}

Consider that:

- a thermal check shall be performed in order to verify that the chosen capacitor does not exceed the max operating temperature at operating I_{RMS}
- the I_{max} of the capacitors has been calculated for a $\vartheta_h - \vartheta_0$ of about 30°C and considering a voltage waveform composed by:
  - a 50Hz fundamental with rms value Urms, having an impact both on conduction losses ($R_S * I^2_{rms}$) and dielectric losses ($Q \tan \delta_0$)
  - a voltage harmonics contents affecting only the conduction losses ($R_S * I^2_{rms}$). In reality the harmonics content affects also the dielectric losses but this can be only evaluated starting from an estimated or measured harmonics spectrum.

THERMAL CHECK

The dissipated power consists of dielectric losses ($Q \tan \delta_0$) due to the polypropylene film and conduction losses ($R_S * I^2_{rms}$) due to the resistance of the electrodes and the connections.

Consider that :
the hot spot temperature can be estimated as follows:
$\vartheta_h = R_{th} * P + \vartheta_0$

the total dissipated power can be calculated as follows:
$P = Q \tan \delta_0 + R_S I^2_{rms}$

At rated duty and hot spot temperature of 85°C the expected lifetime is 100.000 hours with a statistical failure rate of 500FIT (95% survival).

WARNING

The thermal check is based on the hypothesis that the heat generated into the capacitor is transmitted to the environment through the case surface. Possible localised overheating (poor connections, hot components in the nearby as other capacitors, operation with high harmonics frequency etc.) would bring the capacitor to a dramatic failure or to a reduction of the expected life. In case of doubt, special tests by means of thermocouples should be conducted to be sure that the maximum hot spot temperature is not exceeded even under the most critical ambient circumstances.

DEFINITIONS

C_N	Rated Capacitance. It is measured at 20°C, 50Hz, rated U_{rms} voltage
U_{rms}	Rated rms voltage
U_N	maximum operating peak recurrent voltage of either polarity of a reversing type waveform for which the capacitor has been designed.
U_{NDC}	maximum operating peak voltage of either polarity of a non reversing type waveform for which the capacitor has been designed for continuous operation.
U_S	Surge (not repetitive) peak voltage
U_I	rms value of the AC voltage for which the terminal to case insulation has been designed and tested. Unless stated otherwise, the rated insulation voltage should be considered equal to the capacitor's rated rms voltage.
I_{MAX}	Maximum rms current value for continuous operation. Its value depends on the ambient temperature.
Clearance	shortest distance in air between terminals conducting parts or between terminal and case
Creepage	shortest distance along an insulated surface between terminals conducting parts or between terminal and case
q	Reactive power = $2 \times \pi \times f \times C \times U^2_{rms}$
f	Fundamental frequency
R_S	Series resistance i.e. the resistance responsible for the current heat losses ($I^2 x R_S$) in the capacitor.
ESR	Equivalent Series Resistance defined as $ESR = R_S + \tan \delta_0 / (2 \times \pi \times f \times C)$
tan δ_0	Dielectric dissipation factor. It can be considered constant in the normal working frequency range. Typical value for polypropylene is 2×10^{-4}
tan δ	Dissipation factor calculated as follows: $\tan \delta_0 + 2 \times \pi \times f \times C \times R_S$.
dv/dt	Maximum slope of the voltage waveform
I_{PK}	Peak current $I_{PK} = C\ dV/dt$.
P	Active power (losses) = $Q \times \tan \delta_0 + R_S \times I^2_{rms}$
R_{th}	Thermal resistance between the hot-spot in the winding and the environment (natural cooling), so that: $P = (\vartheta_h - \vartheta_0) / R_{th}$ In case of forced air cooling the thermal resistance will be reduced of 20%.
ϑ_h	Hottest point in the capacitor winding = $R_{th} \times P + \vartheta_0$ During stationary operation ϑ_h must not exceed 85° C.
ϑ_0	Operating ambient temperature. It is the air temperature measured under steady conditions, with natural convection at 0,1m from the capacitor case and at two-thirds of the height from its base.
T_C	Temperature coefficient of capacitance. The coefficient is equal to –260 ppm/°C
τ_c	Time constant between terminals: it is the product of insulation resistance between terminals at 20°C and the value of capacitance. The time constant between terminals for the MKV series is in general greater then 3000 s
Ha	Maximum altitude. The max. altitude shall not exceed 2000m corresponding to 0.7 bar
Ln	Expected life at rated voltage U_{rms} and hot-spot temperature of 85°C
L	Expected life at the actual working conditions
L_S	Self inductance of the capacitor. It is due to the internal connections, terminals, winding characteristics and physical dimensions.
λ	Failure rate (FIT) = 10^9 x failures/component x hour

5. TECHNICAL INFORMATION

Ratings
Capacitance tolerance: ±10%, ±5% on request
Useful life: 100.000hrs at 85°C hot-spot, Failure rate: 500FIT

Application
Expressly designed for heavy duty AC applications.
MKV capacitors may be used with dc voltage up to U_{NDC}

Environmental conditions
Operating temperature
ϑ_{min} =-25°C, ϑ_{max} =+85°C (considering mounting position with terminals to the top)
ϑ_{max} is the maximum operating ambient temperature at which the capacitor may operate, for further indication see Selection Rules at paragraph 4;
ϑ_{min} is the minimum operating ambient temperature at which the capacitor may operate;
Storage temperature
ϑ_{min} =-40°C, ϑ_{max} =+85°C
$\vartheta_{max}$is the maximum operating ambient temperature at which the capacitor may be continuously maintained non-operating;
ϑ_{min} is the minimum operating ambient temperature at which the capacitor may be continuously maintained non-operating;

Humidity class
Class F. Max relative humidity 75% annual on average, 95% 30 days per year, condensation not permitted

Design
The winding consists of alternating layers of polypropylene and bi-metallized paper impregnated with oil. The paper does not work as dielectric but it is the means of impregnation and supports the metallization. This technology gives many advantages:
- good impregnation, i.e. long life
- very low losses
- good capability to withstand inrush currents
- reduction of the field strength at the edges of the electrodes

Case material, filler and non metallic parts
Case: aluminium.
Filler and non metallic parts: low smoke and toxicity emission in accordance to UNI CEI 11170-3 GUIDELINES FOR FIRE PROTECTION OF RAILWAY VEHICLES: ACCEPTABILITY LIMITS

Environmental Compatibility
MKV series do not contain PCB and is manufactured in accordance to RohS restrictions

Protection against accidental contact
All the capacitors are NOT protected against accidental contact

Discharge
All the capacitors are NOT provided with internal/external discharge device

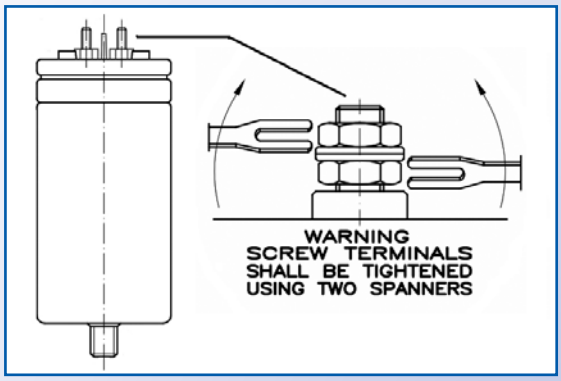
Type of protection
Protected: presence of overpressure disconnector.
The over-pressure disconnector prevents the case bursting due to excess pressure when the capacitor is overloaded or at the end of its life. Total elongation of the case is about 7mm after the over-pressure disconnector release. Don't make use of rigid connections.

Assembly/Cooling
The useful life of a capacitor can be dramatically reduced if exposed to excessive heat. In general, an increase in the ambient temperature of 5°C will halve the expected lifetime. Capacitors must be allowed to cool and should be shielded from external heat sources. Capacitors shall not be placed near to heat source and a minimum clearance of 20mm between the capacitors shall be maintained.

Overvoltages according to IEC 61071

Overvoltage	Maximum duration
1,1 x U_{NDC}	30% of on load duration
1,15 x U_{NDC}	30 min / day
1,2 x U_{NDC}	5 min / day
1,3 x U_{NDC}	1 min /day
1,5 x U_{NDC}	30 ms, no more than 1000 times in the lifetime

Mounting: position, fixing and connection
Capacitors shall be preferably mounted upright, i.e. terminals on top.
The capacitor shall be fixed using the mounting stud present at the base of the can.



Max tightening torque for mounting stud
M8 4 Nm
M12: 10 Nm

To avoid torque trasmission to the capacitor lid during cable connection terminals should be tightened using two spanners.

Recommended torque for screw connections:
M6: 3 Nm
M8: 5 Nm

Failure criteria
Capacitors are considered failed when one of the following conditions happens:
a - short circuit;
b - open circuit;
c - capacitance reduction higher than 3% of the initial value;
d - tan‰ increase over 1.5 times the initial value
e - insulation resistance between terminals and casing less than 10 Gohm.

Operating life
The lifetime of a capacitor depends on the hot spot temperature and on the field strength in its dielectric during operation. The capacitors have been designed for an average probable service life of 100.000hrs at rated duty (voltage, temperature and frequency). During the life of the product the probable failure rate is 500FIT. Failures are considered short circuits, interruptions, capacitance drifts, reduction in the insulation between terminals and casing.
Lifetime is a statistical value calculated on the basis of experience and on theoretical evaluations. It does not have an absolute value and it is not possible to transfer automatically data coming from a limited quantity of capacitors to a whole population or even to a single batch of capacitors.
Please consult our technical department in case of working condition different from the rated ones.

Routine dielectric tests
The performed tests before delivery are the following:
a) capacitance and tan δ measurement with LRC low voltage bridge, 100 Hz frequency;
b) A.C. voltage test between terminals (2.15 U_{rms} for 10s);
c) A.C. voltage test between terminals and case ($2\frac{U_{NDC}}{\sqrt{2}}$ + 1000V for 10s but not less than 2000 V);
d) Sealing test (90°C, 4 h).

Risk Of Explosion And Fire
Capacitors consist mainly on polypropylene film. The film may ignite as a result of internal fault or external overload. Appropriate measures should be ensured to avoid any risk of hazard in the event of failure.
FIRE LOAD: 46MJ/kg, EXTINGUISH WITH: solid extinguish agent, CO2, foam

Reference standard
IEC 61071

Code and Type Designation
The capacitor designation is the following:

MKV - D1X - 47 - 45

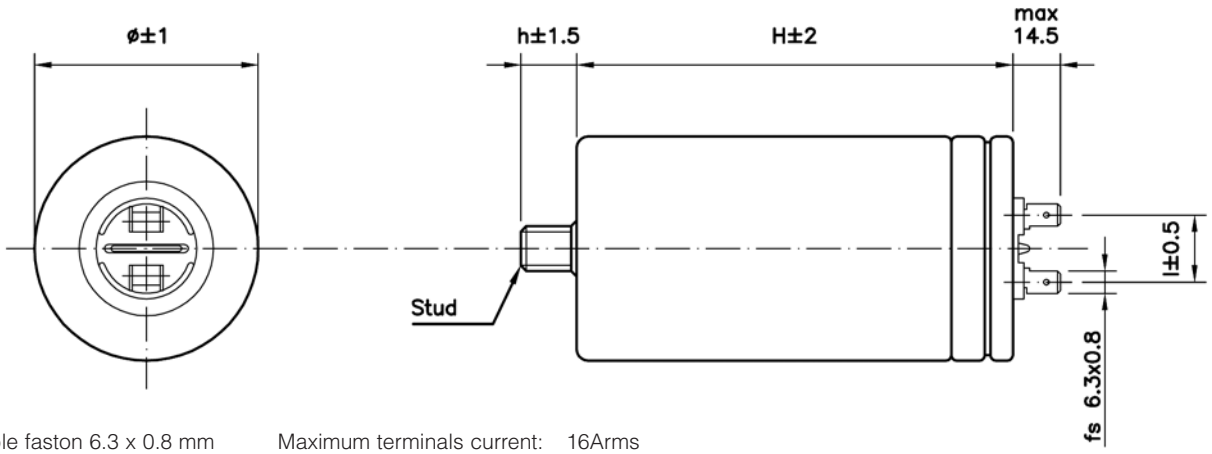
- 45 → Rated r.m.s. voltage code: U_{rms} divided by ten.
- 47 → Rated capacitance code: value in μF.
- D1X → Tolerance code: X = ± 10% J = ± 5%
- MKV → Terminals code **B**: double faston 6.3 x 0.8 mm
  C: M6 screw
  D: M8 screw

MKV - ...

Model	C_N µF	Urms Vrms	U_N V	U_{NDC} V	U_S V	I_{MAX} Arms	I_{PK} A	R_S mΩ	R_{th} °C/W	L_S nH	Fig.	Ø mm	H mm	Weight gr	Stud	h mm	l mm	Creepage mm	Clearance mm
MKV-D1X-47-45	47	450	640	800	1200	37	3150	2,3	6,8	120	3	80	137	820	M12	16	24,0	26	16
MKV-C1X-20-50	20	500	700	1000	1500	25,5	1550	4,7	7,6	130	2	55	147	410	M12	12	18,0	16	11
MKV-B1X-22-50	22	500	700	1000	1500	16,0	1700	7,9	7,5	120	1	60	138	450	M12	12	17,3	12	10
MKV-D1X-33-50	33	500	700	930	1400	35,0	2550	2,7	6,8	120	3	80	137	820	M12	16	24,0	26	16
MKV-B1X-2.2-66	2,2	660	930	1200	1800	13,5	450	8,9	15,5	70	1	35	83	100	M8	10	13,4	8	6
MKV-B1X-15-66	15	660	930	1200	1800	16,0	1450	7,8	8,0	120	1	55	128	350	M12	12	17,3	12	10
MKV-B1X-20-66	20	660	930	1200	1800	16,0	1800	7,9	7,5	120	1	60	138	450	M12	12	17,3	12	10
MKV-D1X-22-66	22	660	930	1200	1800	33,0	2150	3	6,8	120	3	80	137	820	M12	16	24,0	26	16
MKV-C1X-10-75	10	750	1060	1400	2100	23,5	1150	5,3	7,7	120	2	55	137	380	M12	12	18,0	16	11
MKV-B1X-12-75	12	750	1060	1400	2100	16,0	1250	8,9	7,5	120	1	60	138	450	M12	12	17,3	12	10
MKV-C1X-12-75	12	750	1060	1400	2100	23,5	1250	5,4	7,6	130	2	55	147	400	M12	12	18,0	16	11
MKV-D1X-15-75	15	750	1060	1400	2100	31,0	1800	3,5	6,8	120	3	80	137	820	M12	16	24,0	26	16
MKV-D1X-20-75	20	750	1060	1400	2100	34,0	2350	2,9	6,8	120	3	80	137	810	M12	16	24,0	26	16
MKV-B1X-0.1-85	0,1	850	1200	1200	1800	7,5	100	18,6	24,0	60	1	30	63	55	M8	10	13,4	8	6
MKV-B1X-0.22-85	0,22	850	1200	1200	1800	8,5	130	14,8	24,0	60	1	30	63	55	M8	10	13,4	8	6
MKV-B1X-0.33-85	0,33	850	1200	1200	1800	10,0	200	10,6	24,0	60	1	30	63	55	M8	10	13,4	8	6
MKV-B1X-0.47-85	0,47	850	1200	1200	1800	10,5	250	9,0	24,0	60	1	30	63	55	M8	10	13,4	8	6
MKV-B1X-0.68-85	0,68	850	1200	1200	1800	9,5	200	15,9	18,0	70	1	30	83	70	M8	10	13,4	8	6
MKV-B1X-1-85	1	850	1200	1200	1800	12,5	350	10,4	15,5	70	1	35	83	100	M8	10	13,4	8	6
MKV-C1X-1-85	1	850	1200	1400	2100	22,5	600	3,5	14,0	65	2	45	72	140	M8	10	18,0	12	10
MKV-B1X-1.5-85	1,5	850	1200	1200	1800	11,0	300	14,9	13,0	90	1	35	103	120	M8	10	13,4	8	6
MKV-C1X-1.5-85	1,5	850	1200	1400	2100	19,0	500	6,0	11,0	80	2	45	92	180	M8	10	18,0	12	10
MKV-B1X-2.2-85	2,2	850	1200	1200	1800	13,5	450	11,3	11,5	90	1	40	103	150	M8	10	13,4	8	6
MKV-C1X-2.2-85	2,2	850	1200	1400	2100	19,0	550	6,3	10,5	90	2	45	100	190	M8	10	18,0	12	10
MKV-B1X-3.3-85	3,3	850	1200	1400	2100	14,5	550	12,5	9,0	120	1	45	128	230	M8	10	17,3	12	10
MKV-C1X-3.3-85	3,3	850	1200	1400	2100	19,5	700	6,3	10,0	100	2	45	112	210	M8	10	18,0	12	10
MKV-B1X-4.7-85	4,7	850	1200	1400	2100	15,5	700	11,0	9,0	120	1	45	128	230	M8	10	17,3	12	10
MKV-C1X-4.7-85	4,7	850	1200	1400	2100	17,0	650	9,6	8,5	130	2	45	147	270	M8	10	18,0	12	10
MKV-B1X-6.8-85	6,8	850	1200	1400	2100	16,0	1050	9,2	8,0	120	1	55	128	350	M12	12	17,3	12	10
MKV-C1X-6.8-85	6,8	850	1200	1700	2550	23,0	1050	5,9	7,7	120	2	55	137	380	M12	12	18,0	16	11
MKV-B1X-8.2-85	8,2	850	1200	1400	2100	16,0	1100	9,5	7,5	120	1	60	138	450	M12	12	17,3	12	10
MKV-C1X-8.2-85	8,2	850	1200	1700	2550	22,5	1100	6,2	7,6	130	2	55	147	400	M12	12	18,0	16	11
MKV-B1X-10-85	10	850	1200	1400	2100	16,0	1350	8,8	7,5	120	1	60	138	450	M12	12	17,3	12	10
MKV-D1X-12-85	12	850	1200	1700	2550	31	1800	3,5	6,8	120	3	80	137	810	M12	16	24	26	16

The thermal resistance is estimated considering the capacitor alone, not fixed and in free air condition (natural convection)

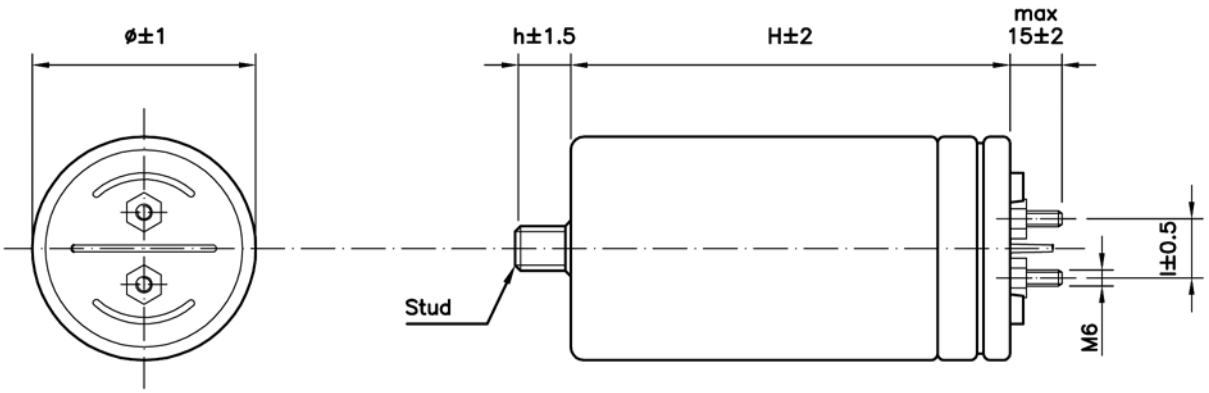
Fig. 1



Type: double faston 6.3 x 0.8 mm
Degree of protection: IP00

Maximum terminals current: 16Arms
Humidity class: F

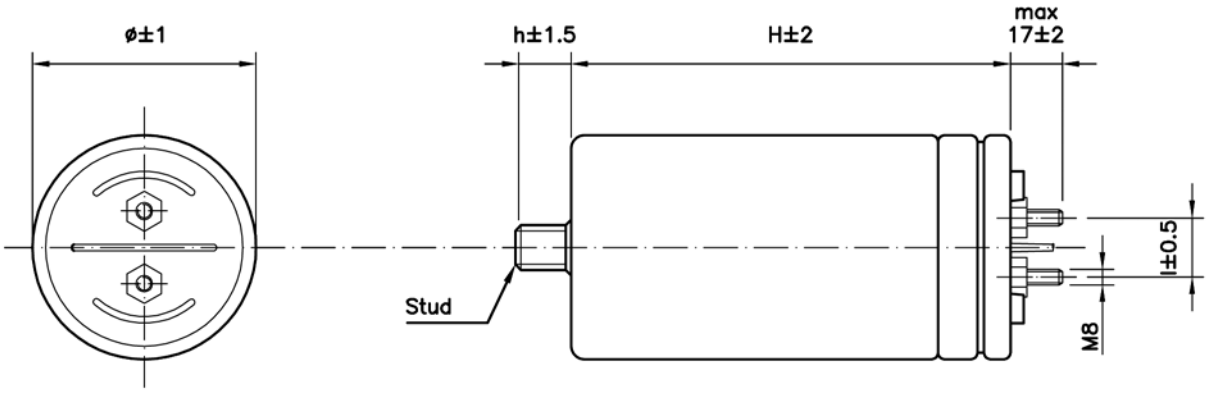
Fig. 2



Type: M6 screw
Degree of protection: IP00

Maximum terminals current: 40Arms
Humidity class: F

Fig. 3



Type: M8 screw
Degree of protection: IP00

Maximum terminals current: 70Arms
Humidity class: F

WARNING

DO NOT MISAPPLY CAPACITORS FOR POWER ELECTRONICS

Icar is not responsible for any kind of possible damages to persons or things, derived from the improper installation and application of Power Electronics capacitors

Most common misapplication forms:

- Ripple current and peak current beyond specification or not according with the maximum power that can be dissipated.
- Surge or working voltage beyond specified value.
- Hot spot or storage temperature beyond the specified limits or not according with the maximum power that can be dissipated.
- Incorrect mounting or wrong installation
  – installation nearby hot components or heat sources
  – not suitable connections (not adequate cable or busbars cross section)
  – nuts and washers material, shape or size not suitable for the application
  – tightening torque not according to the specification
- Unusual service conditions as:
  – mechanical shock and vibrations,
  – corrosive or abrasive conductive parts in cooling air,
  – oil or water vapour or corrosive substances,
  – explosive gas or dust,
  – radioactivity,
  – excessive and fast variations of ambient conditions,
  – service areas higher than 2000 m above sea level.

Periodic check of the connection conditions and tightening torque is strongly recommended.

In case of doubt in choice or in performances of the capacitors **Icar technical service MUST be contacted.**

DISCLAIMER

All the information and data shown in this catalogue are not binding and can be modified without notice. Contact ICAR sales department to get updated specifications.
Reliability data quoted by ICAR are based on statistical evaluations, and does not guarantee properties or performance of each single component.

All the products described in the catalogue shall be used within the limits stated in the technical specifications, nevertheless it is understood that a failure or an abnormal operation, even when capacitors are working within the specified limits, cannot be completely excluded or foreseen at the current state of the art of technology.

Capacitors may become hazardous. Most common risks are related to combustible gas generation, explosion, fire, electrocution or abnormal operation of the capacitor. Not all the possible risks and safety measures are mentioned in this catalogue, further information are available on request.
It is on customer responsibility to select and take all the necessary safety measures in his applications in order to avoid any possible personal injury or property damage related to the use of capacitors. This is valid in particular for applications in which a failure or an abnormal operation of the capacitors could put at risk human life or health.
ICAR SpA and all the persons acting on its behalf, disclaim any and all liabilities for possible damages resulting from the use of the products described in this catalogue or in any other publication.

ICAR reserves the right to discontinue the production of any item without notice.

All orders are subject to ICAR General Conditions of sales – latest revision